APPENDIX

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A. 2001 STREAM PROTECTION STRATEGY BASELINE STUDY UPDATE

1. Introduction

All environmental monitoring relies on repeated observation to provide the most complete picture of environmental processes. In this vein, all county monitoring sites were scheduled to be re-sampled within a five year rotating schedule to both highlight changes in conditions as well as develop a broader information base. Staff began this process in the spring of 2001, collecting biological and habitat data at approximately 25 percent of the original monitoring locations. Specifically, assessments were made at 23 sites randomly selected from the original site list, and at the 11 reference locations within Prince William Forest Park developed as part of the baseline study.

Additionally, seven new sites were added within areas of the county that had been identified as priority assessment areas. Six of these sites were placed on tributaries where no monitoring had yet been conducted but which represented significant drainage areas that had the potential to significantly influence downstream environments. The 7th site, located on the main stem of Little Rocky Run, was established in an attempt to better understand the dramatically different results shown in the baseline study between two adjacent sites. These sub-watersheds will receive updated management category assignments. All 2001 monitoring sites within the county are shown in Figure A1.

Unlike the monitoring conducted in 1999, the 2001 effort included a fish sampling event in the spring (in addition to the annual summer sample). This was done in an effort to understand possible seasonal variations in fish distribution patterns and overall abundance, and their subsequent influence on metric development and scoring. Specifically, large numbers of young-of-year fish were collected and enumerated in the original assessments—which may have led to inflated population measures relative to habitat quality—and it was hoped that early season sampling, prior to emergence and development of fry, would eliminate this potential problem.

2. Results

The Benthic Index of Biotic Integrity scores at the thirty five 2001 resample sites and their rating categories are shown in Table A1 and Figure A1. Overall results show an increase in the proportion of impacted sites when compared to the 1999 baseline study. When plotted against subwatershed impervious surface cover (the major disturbance factor), the benthic index scores for 2001 sites showed good correlation.

Category	Province		Total
	Piedmont	Coastal Plain	
Very Poor	5	1	6
Poor	8	2	10
Fair	14	3	17
Good	0	0	0
Excellent	2	0	2
Total	29	6	35

Table A1: Results of Index of Biotic Integrity based on benthic macroinvertebrates for 2001 sampling locations

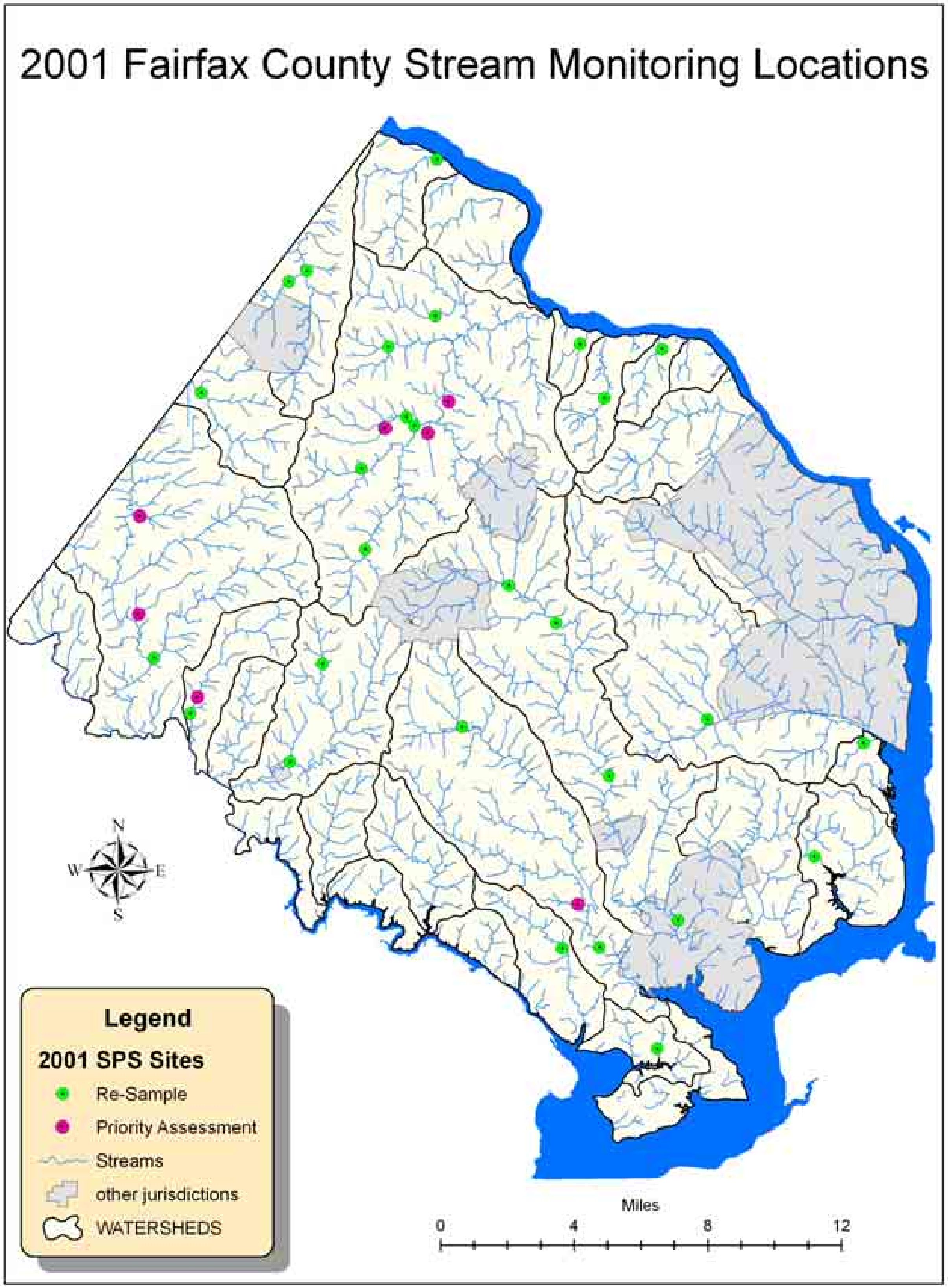


Figure A1: Locations of 2001 biological monitoring sites.

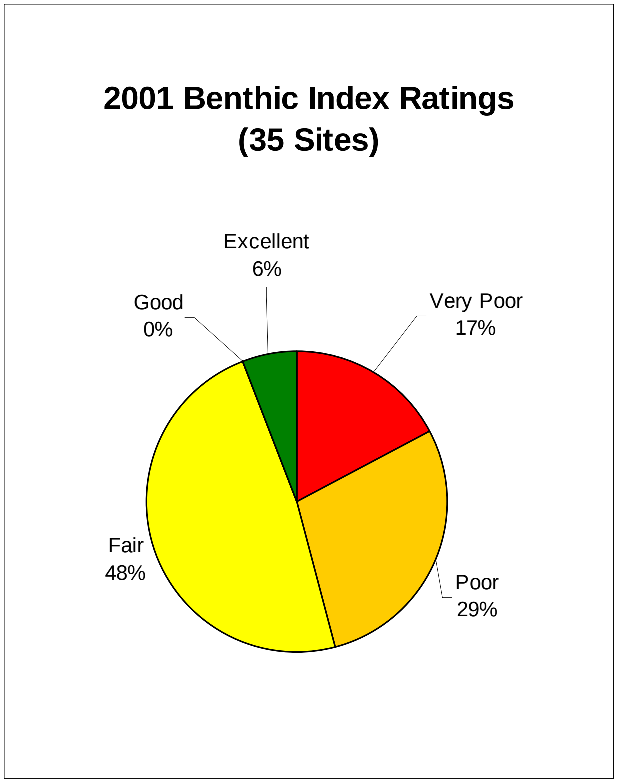


Figure A2: Ratings of 2001 monitoring sites based on the Benthic Index of Biotic Integrity.

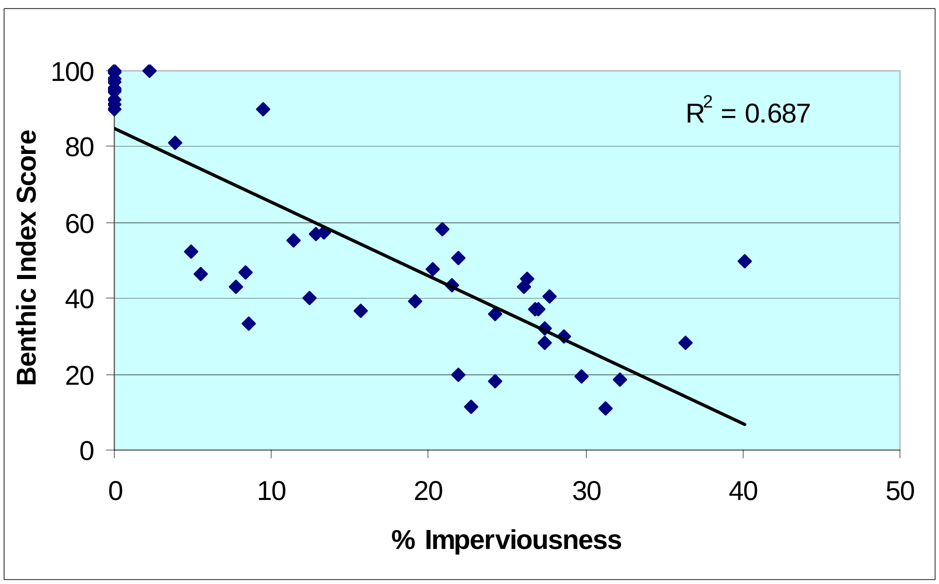


Figure A3: Correlation between the Benthic Index of Biotic Integrity and imperviousness based on 2001 sampling data (includes biological reference sites).

The Index of Biotic Integrity based on fish scores at the thirty four 2001 resample sites and their rating categories are shown in Table A2 and Figure A3. Overall results show a high degree of similarity when compared to the overall 1999 baseline study results.

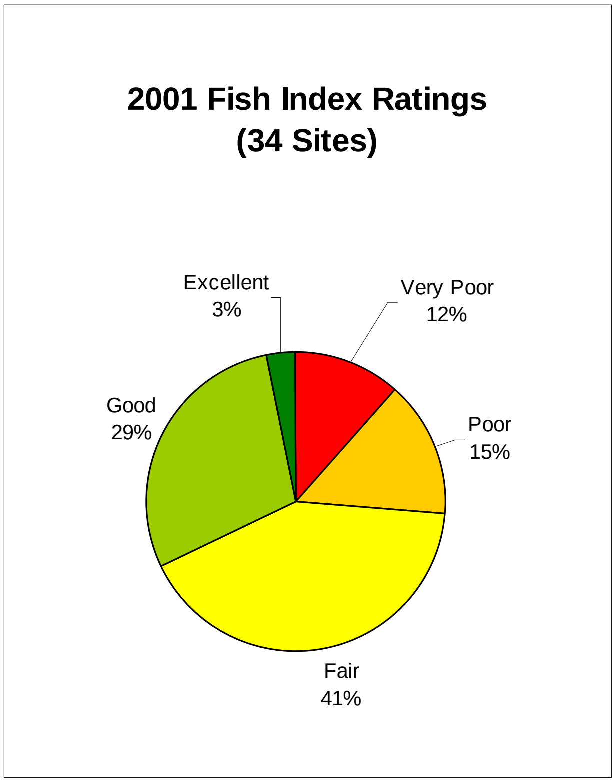


Figure A4: Ratings of 2001 monitoring sites based on the Fish Index of Biotic Integrity.

Table A2: Results of the Fish Index of Biotic Integrity for 2001 sampling locations.

Fish Index Categories	Province		Total
	Piedmont	**Coastal Plain**	
Very Poor	2	2	4
Poor	5	0	5
Fair	11	3	14
Good	9	1	10
Excellent	1	0	1
Total	28	6	34

Results of the spring versus summer fish sampling showed only very minor differences in species counts and total numbers of individuals collected at each of the sampling sites (Figure A3). The data supports continued summer sampling and suggests that spring samples may actually be less representative of actual resident fish populations. One possible explanation for this may be the increased degree of fish migrations in the spring (due to spawning behaviors). Therefore, the annual fish sampling campaign will continue to be performed in the summer season only.

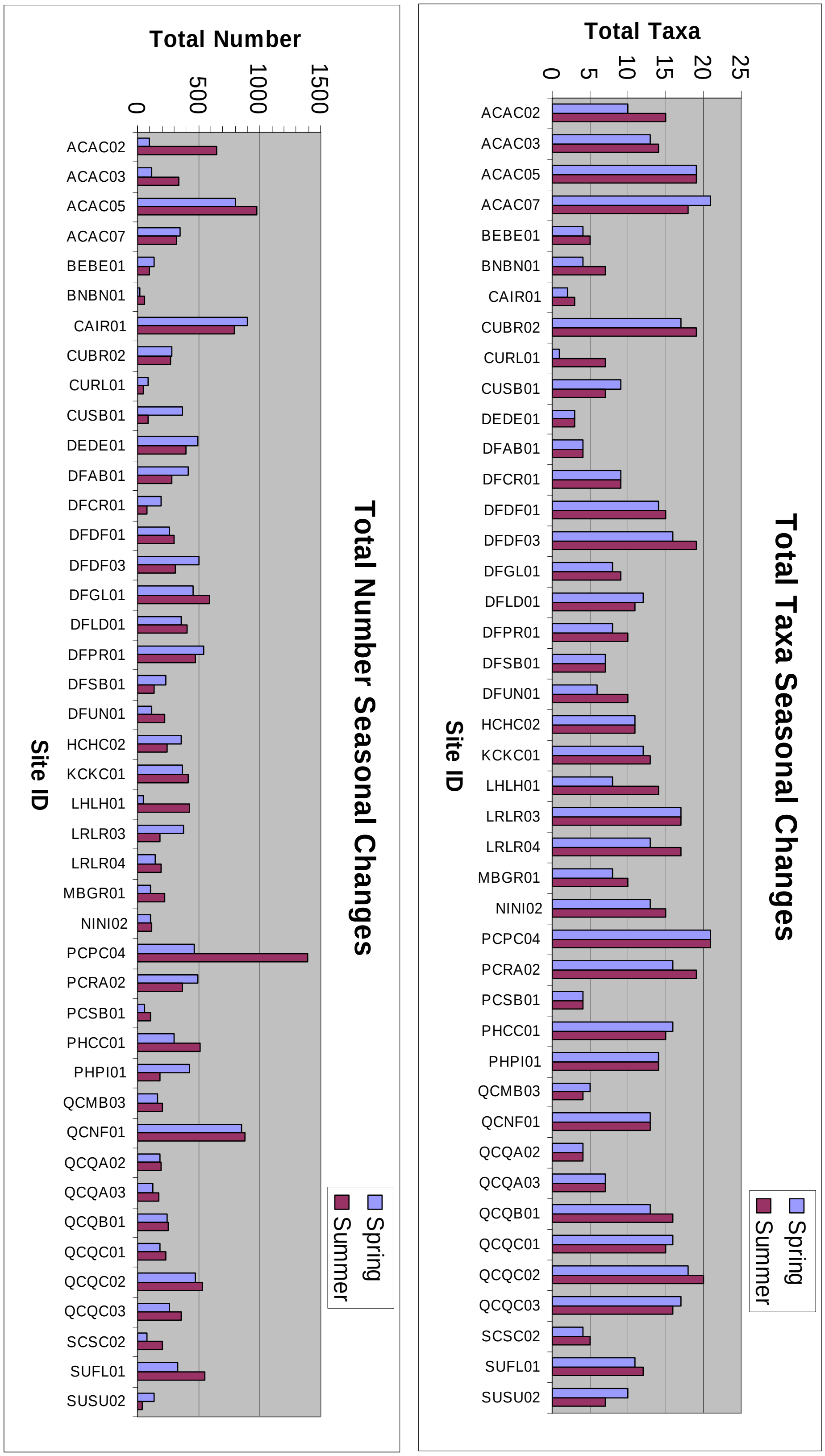


Figure A5: Differences in total taxa and total number of individuals between spring and summer 2001 fish samples

Seven of the original 11 Priority assessment areas identified in the 1999 baseline study were targeted and sampled in the 2001 monitoring effort. These subwatersheds were then incorporated into the original ranking system employed in 1999 (see original baseline study, Chapter 2 – section titled "Countywide Stream Ranking System: Multi-dimensional Curves) for subsequent management category assignment. The values used for this ranking are shown in Table A3 below, and the resultant management categories are shown in table A4. The remaining four priority assessment areas identified in the original study were not sampled due either to access issues, or jurisdictional limitations (i.e.: the Ft. Belvoir Peninsula, Mason Neck National Wildlife Refuge) or because of their very small drainages. These areas were designated as Watershed protection areas, as they are not predicted to have large increases in impervious cover, and currently have very limited development potential. Using this data and an improved method for determining projected percent impervious area for drainage areas, the countywide management category map has been updated for 2001 (Figure A5).

	Composite	**Environmental Variables**			
Watershed, Stream Name and Site Code	Site Condition Rating	Benthic Index	Habitat Score	Fish Taxa Richness	Current % Impervious Cover
1 Cub Run - Round Lick Branch (CURL01)	Poor	40	99	Low	24.2
2 Cub Run - Schneider Branch (CUSB01)	Very Poor	53.5	99	Low	40.1
3 Difficult Run - The Glade (DFGL01)	Good	36.1	129	Moderate	15.7
4 Difficult Run - Angelico Branch (DFAB01)	Poor	60.5	81	Low	7.7
5 Difficult Run - Unnamed Tributary (DFUN01)	Excellent	91.5	128	High	9.5
6 Little Rocky Run - Main Stem (LRLR04)	Excellent	56.8	157	High	20.9
7 Pohick Creek - Unnamed Tributary (PCUN01)	Poor	58.5	82	Low	5.5

Table A3: Results of the additional sites sampled in 2001 to complete the management categories for priority assessment areas.

Watershed, Stream Name and Site Code	**Management Category**
1 Cub Run - Round Lick Branch (CURL01)	Watershed Restoration Level II
2 Cub Run - Schneider Branch (CUSB01)	Watershed Restoration Level II
3 Difficult Run - The Glade (DFGL01)	Watershed Restoration Level II
4 Difficult Run - Angelico Branch (DFAB01)	Watershed Restoration Level II
5 Difficult Run - Unnamed Tributary (DFUN01)	Watershed Protection
6 Little Rocky Run - Main Stem (LRLR04)	Watershed Protection
7 Pohick Creek - Unnamed Tributary (PCUN01)	Watershed Restoration Level II

Table A4: Management categories for priority assessment areas

3. Conclusions

The results in this report are only intended to provide a snapshot of stream quality conditions as they exist today. As such, this first round of (25 percent) baseline study site re-samples should be seen only as the beginning phase of the permanent monitoring effort that will be needed for effective management of aquatic resources within the county. If appropriate decisions are to be made, trends in stream conditions will need to be identified and assessed over the long term.

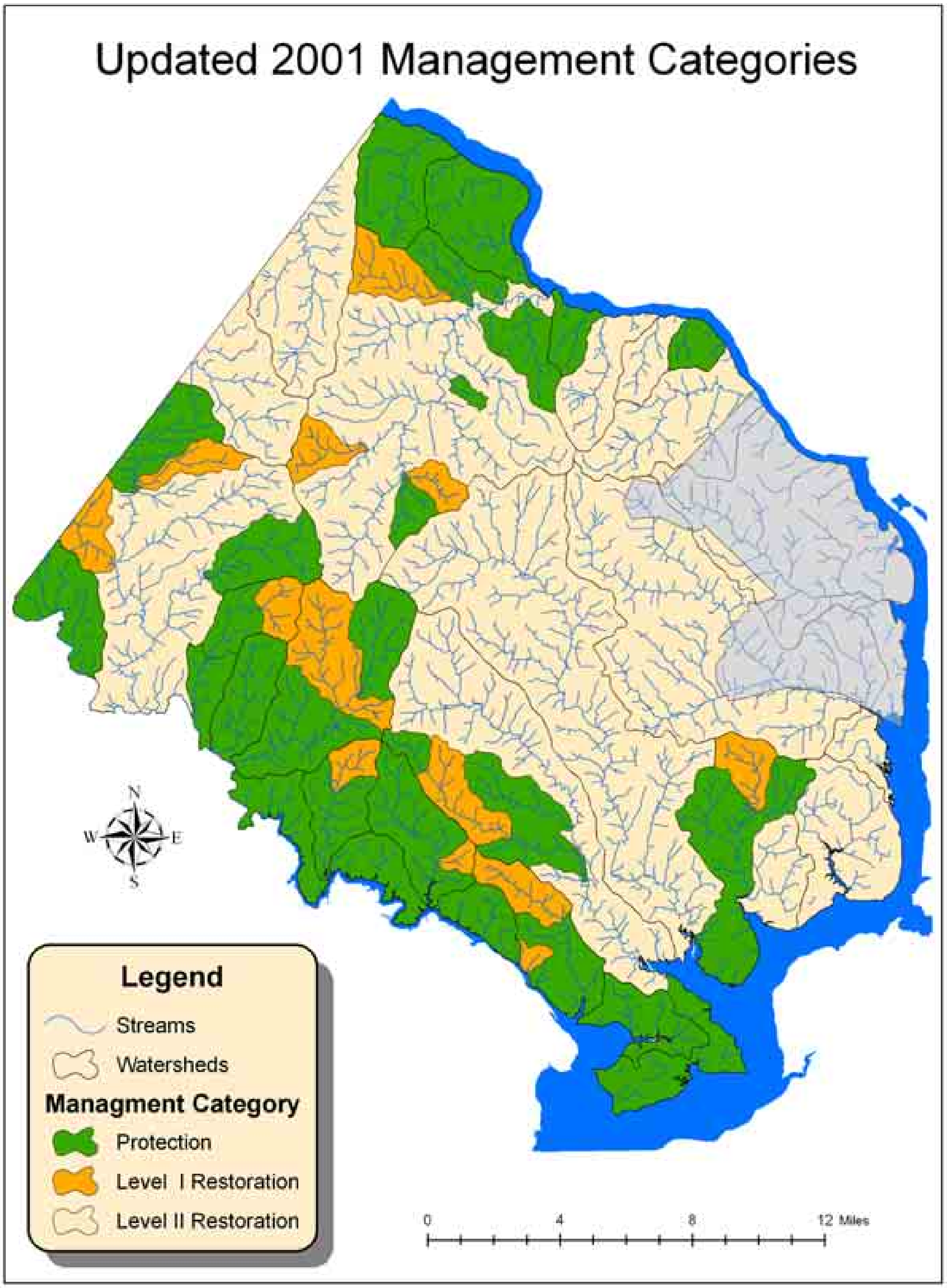


Figure A6: Updated management categories based on 2001 sampling season data.

4. Future directions

Efforts are required to develop a more rigorous sampling procedure for long-term monitoring of county watersheds. The effort will focus on the development of a stratified-random sampling design that will account for accepted variations in stream order, and that will allow for the inclusion of information previously developed form non-randomly selected sites (all monitoring locations established to date). Such an effort will also require the development of spatial information specific to the county's stream coverage, such that the network is separated into 100-meter segments that can then be randomly chosen for future monitoring efforts. The goal will be to have the GIS layers in such a format by December 2002, and to have the design finalized and reviewed by the end of the year so that it can potentially be presented and/or submitted in the spring of 2003.

Uniformity in sampling technique for the collection of macroinvertebrate samples across distinct physiographic provinces has been a concern from the beginning of the program. This concern has been raised by other organizations performing similar monitoring within the mid-Atlantic region. Specifically, the question is over whether or not the RBP kick-sample approached used in riffle/run habitat in the Piedmont produce results that are comparable to the 20-jab methods employed in Coastal Plain steams, environments where the available habitat for macroinvertebrates is much less concentrated and consists of a diverse array of substrate types. Several studies comparing these two methods have shown minimal differences in sample outcomes, and have recommended replacing the kick samples with the 20-jab method. In recognition of these concerns, and the implications they have for the ultimate ranking of county streams relative to each other, macroinvertebrate sampling conducted in the spring of 2002 will include kick-sampling and 20-jab sampling at all monitoring sites within the Piedmont. Subsequent comparisons between the two methods—and across regions—will be used to determine appropriateness of conducting only 20-jab sampling in all future field monitoring.

B. BENTHIC MACROINVERTEBRATE PROTOCOLS

Benthic macroinvertebrate communities are a major component of any healthy stream system. They are an important link in any aquatic food web, forming the core diet of many stream fishes. These organisms are also useful indicators of water quality, due to their short life spans and their varying tolerances to chemical, nutrient, and sediment pollution.

1. EPA's Rapid Bioassessment Protocol Multihabitat Field Sampling Methods

Since Fairfax County contains two different physiographic provinces (Piedmont, and Coastal Plain) that each have a variety of different habitat types, a sampling method that samples all these types of habitats was used. All sites were sampled using the "Twenty Jab" method which was designed by the Mid-Atlantic Coastal Streams Workgroup specifically for streams with variable habitat structure and adopted for use in the protocol (US EPA, 1997), for benthic macroinvertebrate sampling in locations with multiple habitats. Samples collected in the field were preserved with 95 percent ethanol.

The following field equipment was needed for the multi-habitat sampling:

- standard D-frame dip net, 500 µ opening mesh, 0.3 m width (~ 1.0 ft frame width)
- sieve bucket, with 500 µ opening mesh
- 95% ethanol
- sample containers, sample container labels
- forceps
- pencils, clipboard
- Benthic Macroinvertebrate Field Data Sheet
- waders

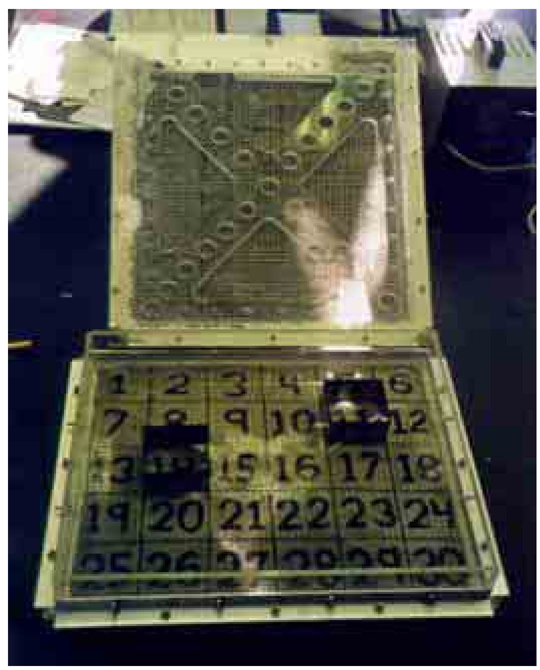
The Quality Assurance and Quality Control (QA/QC) methodology defined by the protocol was followed. The procedure is designed to ensure that the data collected complies with the Goals and Objectives set forth in the introduction chapter of the SPS Baseline Study. Specific procedures are outlined in separate sections where applicable.

2. Laboratory Identification and Analysis

The following laboratory equipment was used to identify, record, and catalog the benthic macroinvertebrate samples:

- benthic sample
- 8-inch diameter sieve with 500 µ mesh sorting grid, (30 squares) with 500 µ mesh
- polyethylene wash tray
- dissecting microscope
- fiber-optic light source
- 95% ethanol
- sample vials
- 9-unit laboratory counter with grand total counter
- extra-fine/jewelers forceps
- chain-of-custody form and QA/QC log in sheets
- benthic macroinvertebrate laboratory bench sheets (Figures Figure B1and Figure B2)

View of top and bottom of sub-sampler built by staff.



Upon arrival in the lab, field samples were logged in. Invertebrate collections were developed by spreading each respective sample over the surface of a 30 x 36 cm, 500 µ mesh sorting grid sub-sampler (Caton, 1991) (Figure B1). A sub-sample of individuals was picked from a randomly selected square subdivision marked on the grid's surface (30 total squares). A tally of specimens continued until a minimum of 200 (plus or minus 20 percent) was obtained. If the square containing the 200th individual would result in more than 240 individuals, that square was then subsampled until the total reached was less than 240. The specimens for each site were then transferred to a sample vial, preserved with 95 percent ethanol, and labeled with the following information:

- Site code
- Date collected
- Date sorted
- Sorted by
- Total number of organisms in the sample (chironomidae, oligochaeta, others)

In compliance with protocols, after laboratory processing was completed for a given sample, all sieves, pans, trays, etc., that had come in contact with the sample were rinsed thoroughly, examined carefully, and picked free of organisms or debris. Organisms found were added to the sample residue.

Once all site samples were sub-sampled, sorted, and labeled, taxonomic identifications were then made to the genus level. Genus level classification of all macroinvertebrates samples was performed using selected taxonomic keys (Pennak 1989, Peckarsky 1990, Wiggins 1995, Merritt and Cummins 1996). However, time constraints prevented the more detailed examinations required to identify taxa such as aquatic worms (Oligochaeta) and midge larvae (Chironomidae) to this level. In such cases, oligochaetes were identified at the class level, and chironomids were identified at the family level. The representatives in each respective taxonomic grouping were enumerated and recorded on the macroinvertebrate data bench sheet and on the sample identification log-in sheet. All individuals from the sub-sample were then returned to the 95 percent ethanol solution and archived. To ensure conformity with protocols, these additional steps were taken:

- Ten percent of the already processed and identified samples were randomly selected and rechecked for taxonomic and numerical consistency.
- A voucher collection of all samples and sub-samples was maintained. These specimens were properly labeled, preserved, and stored in the laboratory for future reference.

Figure B1: Benthic Identification Bench Sheet (front page).

SITE ID: ___________________

Benthic Macroinvertebrate Identification Sheet		
Taxonomist:		**Identification Start Date:**
		Identification Finish Date:
Watershed:		**Sorting Date(s):**
		Collection Date:
Subsample Target: 200 Organisms		
		Number sorted:
QC Sample? Y N	**QC Site? Y N**	**Number ID'ed:**

Organisms			**#**	**L.S.***	**T.I.**
Order	**Family**	**Genus**			
Oligochaeta				A	
Chironomidae				L	
Hirudinea					
Isopoda					
Amphipoda					
Decapoda					
Ephemeroptera					
Plecoptera					
Odonata					
		Subtotal:			

***Lifestages: A (Adult), P (Pupae), L (Larvae)**

Figure B2: Benthic Identification Bench Sheet (back page).

SITE ID: ____________________

Benthic Macroinvertebrate Identification Sheet

Organisms			#	L.S.*	T.I.
Order	Family	Genus			
Trichoptera					
Hemiptera					
Megaloptera					
Coleoptera					
Diptera					
Gastropoda					
Bivalves					
Acariformes					
Other					
		Subtotal:			
		Grand Total:			

***Lifestages: A (Adult), P (Pupae), L (Larvae)**

3. Development of a Benthic Macroinvertebrate Index of Biotic Integrity

The response of a given biological community to environmental degradation can provide a useful measure of overall system health. Such responses, often evident as changes in community structure and composition, can highlight single-source environmental stressors, or the cumulative impact of multiple stressors. Potential measures of relative tolerance and intolerance to stressors will be identified from within the various subcategories (i.e., genus, functional feeding group, and habitat) of the macroinvertebrate communities.

These attributes, or "metrics," were used to construct the foundation of an Index of Biotic Integrity (IBI) for ranking each study site. The index has two distinct components; (1) a set of criteria which transforms the metric values into scores that can then be used in the aggregate and (2) narrative "integrity" classes (excellent, good, fair, poor and very poor) which reflect relative correspondence to the numeric rating of the "reference" condition (Table B1).

Table B1: Classification ratings used on the Benthic Macroinvertebrate Index of Biotic Integrity scores.

INDEX SCORE	RATING	DESCRIPTION
80 to 100	Excellent	Equivalent to reference conditions; High biodiversity and balanced community
60 to 80	Good	Slightly degraded site with intolerant species decreasing in numbers
40 to 60	Fair	Marked decrease in intolerant species; shift to an unbalanced community
20 to 40	Poor	Intolerant species rare or absent, decreased diversity
0 to 20	Very Poor	Degraded site dominated by a small number of tolerant species

For the benthic macroinvertebrates, indices were created separately for the Piedmont and the Coastal Plain area. An index was created for the Coastal Plain province using metrics taken from the Mid-Atlantic Integrated Assessment data report

Table B2), *Assessment Framework for Mid-Atlantic Coastal Plain Streams Using Benthic Macroinvertebrates* (Maxted et al. 1999). For the Piedmont the Index of Biotic Integrity (Jones 2000, personal communication) was used since it provided regionally tested metrics and multi-year data for the same reference sites which were used in the baseline study (Table B3).

Table B2: Index of Biotic Integrity metric descriptions for benthic macroinvertebrates for Coastal Plain. (Based on Maxted et al. 1999).

COASTAL PLAIN INDEX METRICS	
METRIC	**DESCRIPTION**
1. Taxa Richness	**Number of different taxa at a site**
2. EPT Taxa	**Number of Mayfly, Stonefly and Caddisfly taxa at a site**
3. Percent Ephemeroptera	**Percent of sample that was in the order Ephemeroptera**
4. Hilsenhoff Biotic Index	**Hilsenhoff Biotic Index - general tolerance/intolerance of the sample**
5. Percent Clingers	**Percent of individuals whose habitat type is clingers**

Table B3: Index of Biotic Integrity metric descriptions for benthic macroinvertebrates for the Piedmont (Jones 2000, personal communication).

PIEDMONT INDEX METRICS	
METRICS	**DESCRIPTIONS**
1. Taxa Richness	**Number of different taxa at a site**
2. EPT richness	**Number of Mayfly, Stonefly and Caddisfly taxa at a site**
3. Percent EPT	**Percent of sample that are Mayfly, Stonefly and Caddisfly excluding the tolerant Net-Spinning Caddisflies (Hydropsychidae)**
4. Percent Trichoptera w/o Hydropsychidae	**Percent of sample that are Caddisflies excluding the tolerant Net-Spinning Caddisflies (Hydropsychidae)**
5. Percent Coleoptera	**Percent of sample that are beetles**
6. Family Biotic Index	**General tolerance/intolerance of the sample**
7. Percent Dominance	**Percent of the most abundant taxa**
8. Percent Clingers + Percent Plecoptera	**Percent of individuals whose habitat type is clingers plus percent of sample that are stoneflies but are not clingers**
9. Percent Shredders	**Percent of individuals that uses shredding as its primary functional feeding group**
10. Percent Predators	**Percent of individuals that uses predation as its primary functional feeding group**

Example 1: For metric values that decrease with increasing disturbance (Total Taxa, EPT Richness, % EPT w/o Hydropsychidae, % Trichoptera w/o Hydropsychidae, % Coleoptera, % Clingers plus % Plecoptera, % Clingers, % Shredders, % Ephemeroptera and % Predators).

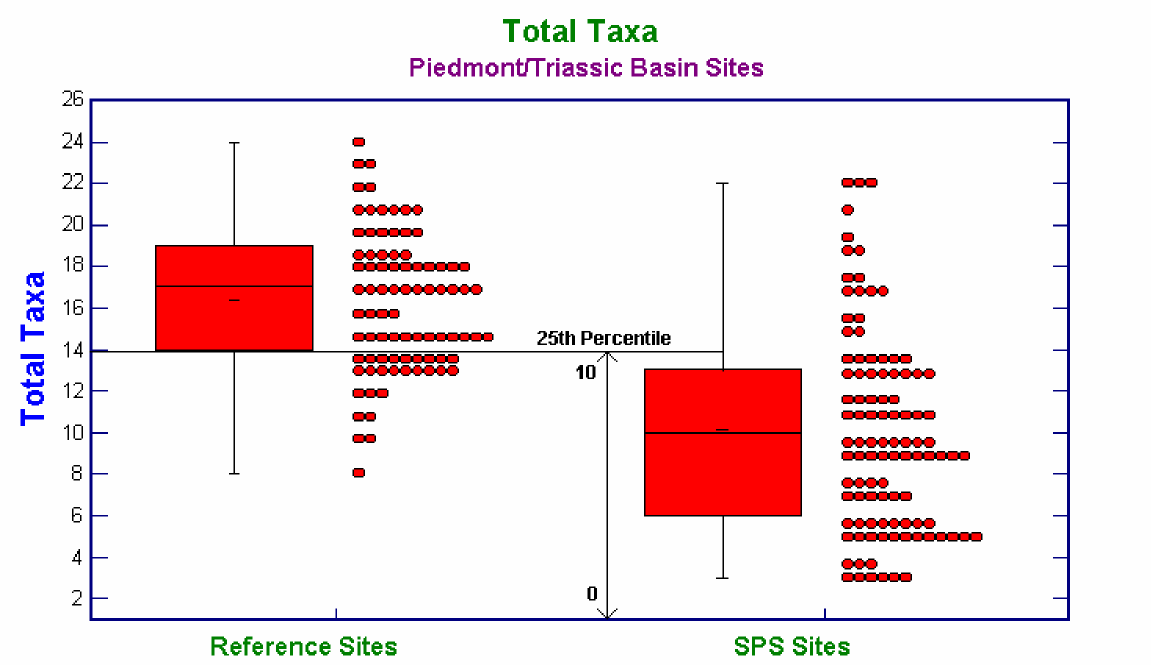


Figure B3: Box and Whisker Plot of Total Taxa for the Piedmont.

The data for total taxa from the Piedmont reference areas and the total taxa data were plotted against each other using a box and whisker plot. The 25th percentile from the reference data was then designated as the "reference condition" value. Therefore, any value above that mark was considered equivalent to reference conditions. The 25th percentile value of the reference data was then divided by 10 to obtain the conversion factor. In this example (Figure B3) the conversion factor would be 14 (the 25th percentile of the reference conditions) divided by 10 (the upper limit of the 10-point scale), which is 1.4. All the county site values for total taxa were then divided by the conversion factor to convert them to the final 0 to 10 scale (Table B4). If the resulting value was more than 10, it was rectified to 10. The resulting values for all metrics were then summed to give each site a rating between 0 – 100. Each site was then given a qualitative ranking based on its final rating (Table B1).

Table B4: Metric value conversions for Example 1.

Site Values	Converted Values	Final Value
7	5	5
10	7.14	7.14
22	15.71	10
13	9.29	9.29
8	5.71	5.71
5	3.57	3.57
4	2.86	2.86
14	10.00	10
6	4.29	4.29
3	2.14	2.14
17	12.14	10

These steps were also performed for the Coastal Plain site data. Unlike the Piedmont sites however, for which spatially and temporally broad reference information was available, the Coastal Plain sites were only compared to the Kane Creek site. The metric scores for the Kane Creek site were used in lieu of the 25th percentile of aggregate reference data for inversely-correlated metrics (Total Taxa, EPT Richness, % Ephemeroptera and % Clingers).

<u>Example 2</u>: For metric values that increase with increasing disturbance (i.e. FBI, HBI and Percent Dominance).

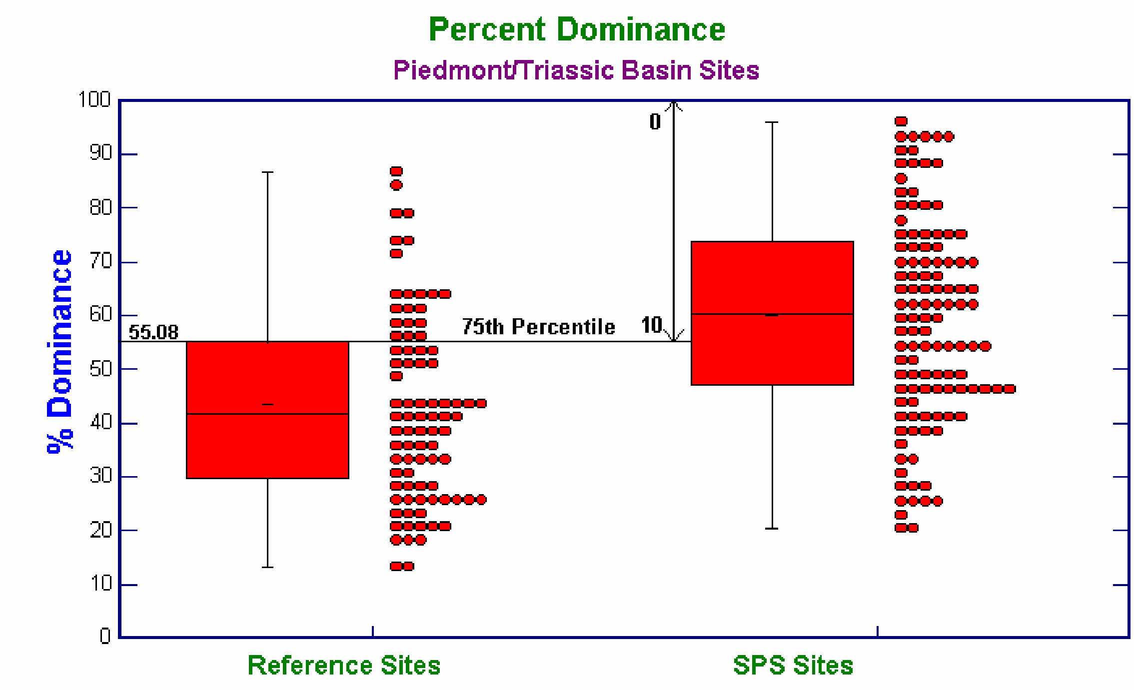


Figure B4: Box and Whisker Plot of Percent Dominance for the Piedmont.

The data for percent dominance from the Piedmont reference areas and the data were plotted against each other using a box and whisker plot. In this case, the 75th percentile from the reference data was designated as the "reference condition" value. The difference between these metrics and those from example 1 is that the best value obtainable is 0 for the metric instead of 100, and the 75th percentile of the reference data, rather than the 25th, is the 10 value on the 0 to 10 scale. In this example (Table B4), 100 percent dominance is the 0 value and 55.08 is the 10 value. In order to obtain the conversion factor, the 75th percentile value for the reference condition was subtracted from its upper limits. This value was then divided into 10 to arrive at the conversion factor. So in this example, the 75th percentile (55.08) is subtracted from the upper limit of this metric (100) to give 44.92. The final step to obtain the conversion factor is to divide 44.92 by 10, which yields 4.492. Individual values from the monitoring sites for percent dominance were then taken and subtracted from 100. Each value was then divided by the conversion factor to give the 0 to 10 value for that site (Table B5). If the value exceeded 10, the site was given a value of 10. This procedure was also followed for the coastal plain sites using the coastal plain reference data. The converted values for each site were then summed to form a 0 to 100 scale. Since the coastal plain index consisted of only 5 metrics, the summed total was doubled to give it a 0 to 100 range (Table B1).

Table B5: Metric value conversions for Example 2.

SPS Site Value	100 - SPS site	Converted Value	Final Value
59.38	40.62	9.04	9.04
49.03	50.97	11.35	10
94.44	5.56	1.24	1.24
88.79	11.21	2.50	2.50
82.14	17.86	3.98	3.98
58.74	41.26	9.19	9.19
90.70	9.30	2.07	2.07
95.83	4.17	0.93	0.93
76.87	23.13	5.15	5.15
95.88	4.12	0.92	0.92
50.72	49.28	10.97	10
49.63	50.37	11.21	10

These steps were also performed for the Coastal Plain site data. Unlike the Piedmont sites however, for which spatially and temporally broad reference information was available, the Coastal Plain sites were only compared to Kane Creek. The averaged metric scores for the two Kane Creek sites were used in lieu of the 75th percentile of aggregate reference data for the one directly correlated metric (Hilsenhoff Biotic Index).

4. 2004 Results at Individual Sites

Table B6: Index(out of 100) and ratings for the 2004 sampling locations based on benthic macroinvertebrate data.

SiteID	Stream Order	Benthic Index Score	Rating
Accotink Creek (AC0401)	3	30.07	Poor
Accotink Creek (AC0402)	3	25.62	Poor
Accotink Creek (AC0403)	1	40.71	Fair
Accotink Creek (AC0404)	2	21.26	Poor
Belle Haven (BE0401)	2	15.91	Very Poor
Cameron Run (CA0401)	2	37.48	Poor
Cameron Run (CA0402)	1	19.05	Very Poor
Cub Run (CU0401)	4	51.53	Fair
Difficult Run (DF0401)	5	85.01	Excellent
Difficult Run (DF0402)	2	53.42	Fair
Difficult Run (DF0403)	2	25.22	Poor
Difficult Run (DF0404)	1	45.25	Fair
Difficult Run (DF0405)	1	15.91	Very Poor
Difficult Run (DF0406)	1	27.34	Poor
Difficult Run (DF0407)	1	71.19	Good
Difficult Run (DF0408)	1	13.56	Very Poor
Kane Creek (KC0401)	1	37.59	Poor
Little Hunting Creek (LH0401)	1	23.43	Poor
Little Hunting Creek (LH0403)	2	13.67	Very Poor
Little Rocky Run (LR0401)	3	27.36	Poor
Little Rocky Run (LR0402)	1	30.80	Poor
Little Rocky Run (LR0403)	1	15.56	Very Poor
Nichol Run (NI0401)	1	79.37	Good
Occoquan (OC0401)	1	86.99	Excellent
Pohick Creek (PC0401)	3	17.81	Very Poor
Pohick Creek (PC0402)	1	70.08	Good
Pohick Creek (PC0403)	1	29.44	Poor
Popes Head Creek (PH0401)	2	27.86	Poor
Sugarland Run (SU0401)	4	44.76	Fair
Sugarland Run (SU0402)	1	61.16	Good

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C. FISH SAMPLING PROTOCOLS

1. Rapid Bioassessment Protocol Field Sampling Methods

Fish assemblages represent the apex of most stream communities. Fish typically are at the top of the food web and are sensitive to both natural and anthropogenic changes within a given system and are, therefore, useful indicators of stream ecosystem health. Fish are also more readily understood and appreciated by the public than are other biological components of streams systems. Therefore, they can be useful tools for developing community interest in environmental and water management issues. The methods employed were based largely upon the EPA's Rapid Bioassessment Protocols V (Barbour et al. 1999). Because of sporadic and sparse occurrence of fish assemblages in first order and intermittent headwater streams, the value and validity of using these assemblages as ecosystem health indicators is questionable. As such, all fish communities were sampled from non-tidal freshwater, perennially-flowing, second order (or greater) streams within Fairfax County.

The following equipment was used for sampling:

- Smith-Root, Model 12-B, 400 watt, backpack electrofisher (battery powered),
- 12-volt DC batteries (2 to 4) for electrofisher,
- rubber gloves (high-voltage rated, insulated),
- chest waders and belts for all participants,
- hand dip-nets, both long- and short-handled (1/8 inch mesh),
- block nets (i.e., seines),
- buckets and live car(s) for fish storage and transport,
- data sheets (Figure C1),
- data log (waterproof) and pencils,
- buffered formalin (17 percent formaldehyde),
- specimen jars,
- waterproof jar labels, and
- species key and field guide (Jenkins and Burkhead, 1994).

2. Fish Sampling, Identification, and Preservation

Using single or multiple battery powered backpack electrofishing units (Smith-Root, model 12), a single sample pass was made through the selected 100-meter reach (number of units will be dependent upon stream width and depth). A block net was deployed at the uppermost reach boundary, and the sample was conducted in the upstream direction. To minimize the risks of mortality or injury to fish, electrofisher unit settings were adjusted to reflect stream water conductivity and corresponding manufacturer recommendations.

Captured specimens were transported in water-filled buckets and maintained in a portable in-stream live car for subsequent examination. Fish were identified to the species level and the representatives in each category were enumerated and recorded. Special note was made of individuals with eroded fins, parasites, tumors, lesions, hemorrhaging, eye maladies and/or other abnormalities (see bottom of Figure C2). Upon final identification, the fish were then released back into the stream. As is the standard practice with fish sampling protocols, juvenile or young-of-year specimens, determined to be those individuals under 20 mm total length, were not counted towards the species counts. This is due to their higher mortality rates in the first year of life, as well as ambiguities (or incomplete development) in proper morphological characteristics necessary for accurate identifications in certain species.

Positive field identification is particularly difficult with some specimens, and preservation of representative individuals, in some cases, may be needed for more detailed laboratory examinations. Other specimens were preserved as part of the development a permanent reference collection of fishes found within Fairfax County. Samples were preserved in a fixative of 10 percent formalin for long-term storage. All specimen collections were carried out in accordance with the guidelines set forth in the current Virginia Department of Game and Inland Fisheries (DGIF) Scientific Collection Permit issued to Fairfax County Ecologists.

A uniform fish sampling data sheet is used during the fish sampling session (Figures C1 & C2) for all county streams.

Figure C1: Fish sampling field data sheet (front).

RBP Coastal Plain Assessment Scores	
Parameter	**Score**
1) Epifaunal Subs./Available Cover	_________
2)Pool Substrate Characterization	_________
3) Pool Variability	_________
4) Sediment Deposition	_________
5) Channel Flow Status	_________
6) Channel Alteration	_________
7) Channel Sinuosity	_________
8) Bank Stability	RB:_______ LB:_______
9) Bank Veg. Prot.	RB:_______ LB:_______
10) Rip. Veg. Zone Width	RB:_______ LB:_______

RBP Piedmont Assessment Scores	
Parameter	**Score**
1) Epifaunal Substrate	_________
2) Embeddedness	_________
3) Velocity-Depth Regimes	_________
4) Sediment Deposition	_________
5) Channel Flow Status	_________
6) Channel Alteration	_________
7) Frequency of Riffles (or Bends)	_________
8) Bank Stability	RB:_______ LB:_______
9) Bank Vegetative Protection	RB:_______ LB:_______
10) Rip. Veg. Zone W.	RB:_______ LB:_______

Water quality	
Temperature	_________
% saturation:	_________
Dissolved oxygen	_________
Conductivity	_________
Specific conductance	_________
pH	_________
Turbidity	_________

Category	Value
# of tree falls	_________
# fish barriers	_________
# of large point bars	_________
# of log jams	_________

Weather Conditions	Today:	storm/heavy rain	showers (intermittent)		partly cloudy	
		rain (steady)	sunny	partly sunny		cloudy (overcast)
	Past 24 hrs:	storm/heavy rain	showers (intermittent)		partly cloudy	
		rain (steady)	sunny	partly sunny		cloudy (overcast)
	Has there been a heavy rain in the past 7 days?		Yes	No		
	Estimated Air Temperature_______________					

Riparian zone/ instream features	**Predominant Surrounding Landuse**			**Local water erosion**			
	forest		commercial	none	moderate	heavy	
	field/pasture		industrial				
	agricultural		other_____	**Channelized**		yes	no
	residential		other_____				
		Canopy cover		**Local watershed NPS pollution**			
	open	moderate	shaded	no evidence	potential sources		obvious sources

Water	Odors:	normal	sewage	fishy	petroleum	chemical	other_______
	Oils:	none	sheen	globs	slick	flecks	other_______
	Color:	clear	greenish	brownish	other_______		

Comments:

Figure C2: Fish sampling field data sheet (back).

Date:	**Sampling start time:**	**Number of Electorfisher units:**
Site Code:	**Sampling finish time:**	**Gear:** block nets (1/4" mesh) size ______, dipnets (1/8" mesh), backpack electrofisher(s), buckets, livewell(s)
Stream Name:	**Recorder:**	
Stream Order:	**Electrofisher operator(s):**	
Drainage basin:	**Investigators:**	**Electrofisher settings:**
Protocol: EPA RBP		

Species	**Number of Individuals** (Record with tally marks)	**Total**	**Comments**
Ameiurus natalis			
Ameiurus nebulosus			
Anguilla rostrata			
Campostoma anomalum			
Catostomus commersoni			
Clinostomus funduloides			
Cyprinella spiloptera			
Cyprinella analostana			
Erimyzon oblongus			
Etheostoma olmstedi			
Etheostoma flabellare			
Exoglossum maxillingua			
Fundulus diaphanus			
Gambusia holbrooki			
Hypentelium nigricans			
Lampetra aepyptera			
Lepomis auritus			
Lepomis cyanellus			
Lepomis gibbosus			
Lepomis macrochirus			
Lepomis microlophus			
Luxilus cornutus			
Micropterus salmoides			
Nocomis micropogon			
Notemigonus chrysoleucas			
Notropis hudsonius			
Notropis procne			
Noturus insignis			
Pimephales notatus			
Rhinichthys atratulus			
Rhinichthys cataractae			
Semotilus atromaculatus			
Semotilus corporalis			
	Grand Total:		

D=deformity, E=eroded fin, L=lesion, T=tumor, F=fungus, W=wound, I=eye malady, H=hemorrhage, P=parasite

3. Development of a Fish Index of Biotic Integrity for Fish

Fish species were first classified into groups including trophic guilds and tolerance values. Karr et al. (1986) recommended that less than 10 percent of a community be labeled “intolerant” and Karr and Chu (1997) furthered defined that by recommending that 5 – 15 percent of species in a community be designated as tolerant or intolerant. Designations of tolerant or intolerant in Fairfax County were based on field observational data. Trophic and habitat classifications were based on the literature (Smogor 1999, and Teels 2001)(Table C1).

An extensive suite of candidate metrics were evaluated based on trophic characteristics, tolerance, and community structure, and each was then assessed for its usefulness in developing an Index of Biotic Integrity for fish. Metrics and scoring criteria that were tested were similar to those tested by Billy Teels whose work was completed in the Occoquan watershed in 2001 (Teels 2001). In addition metrics and scoring criteria used by the statewide Maryland Biological Stream Survey were also tested (Southerland, personal communication). Metrics were chosen on their ability to correlate with imperviousness, and their ability to distinguish between most impaired sites from least impaired sites (Figure C3).

Studies have shown that there is a significant difference in fish assembalages in the Coastal Plain versus the Piedmont (Smogor 1999, and Roth et al. 2000). A small portion of Fairfax County is in the Coastal Plain, but there are few undisturbed or reference areas available in this small portion. The fish index for the Coastal Plain will be based on metrics and scoring criteria used in Maryland Coastal Plain streams (Southerland, personal communication)(

Table C2). The scoring criteria for the “percent tolerant” metric was adjusted because differences in number of species designated as tolerant between the studies. Metrics used for Piedmont streams are similar to those used by Teels. Scoring criteria was based on 1999 data and was determined using the tri-sectioning method as detailed by Fausch et al. (1984) and Karr (1986) and results are similar to Teels (Figure C4). Further refinement of the metrics and/or scoring criteria could occur in the future as more data is collected particularly for the Coastal Plain.

Classification ratings were based on the maximum and minimum score and five categories were created from the difference. There was no “Excellent” category for Coastal Plain streams because it was known that a stream in the Coastal Plain isn’t in “Excellent” condition because attempts were made to find one for a reference location (Table C3).

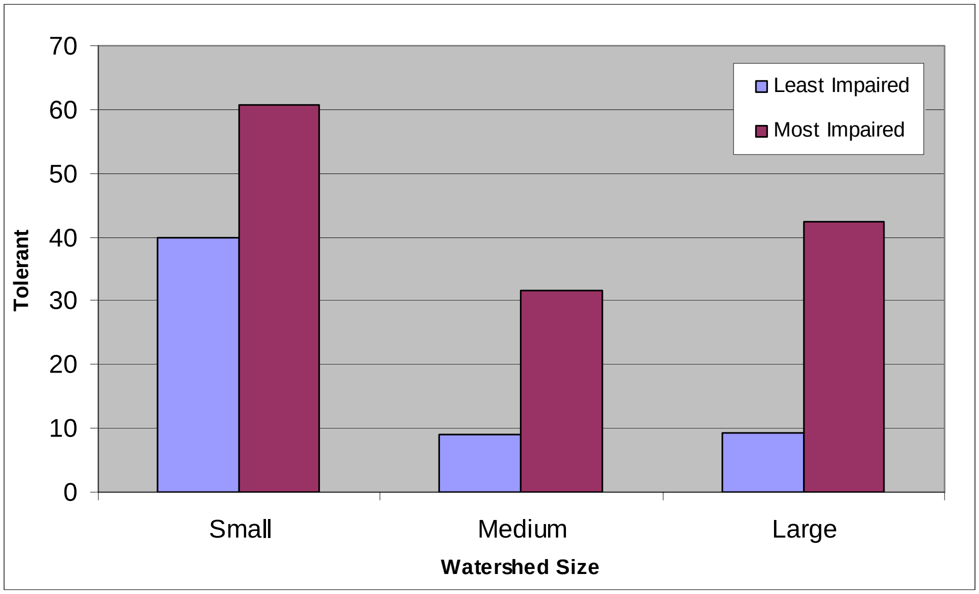
The results of the fish community analysis for 1999 are presented here because the analysis was not previously presently (Figure C5, Figure C6).

Table C1: Trophic guilds and tolerance ratings for fish species found within Fairfax County.

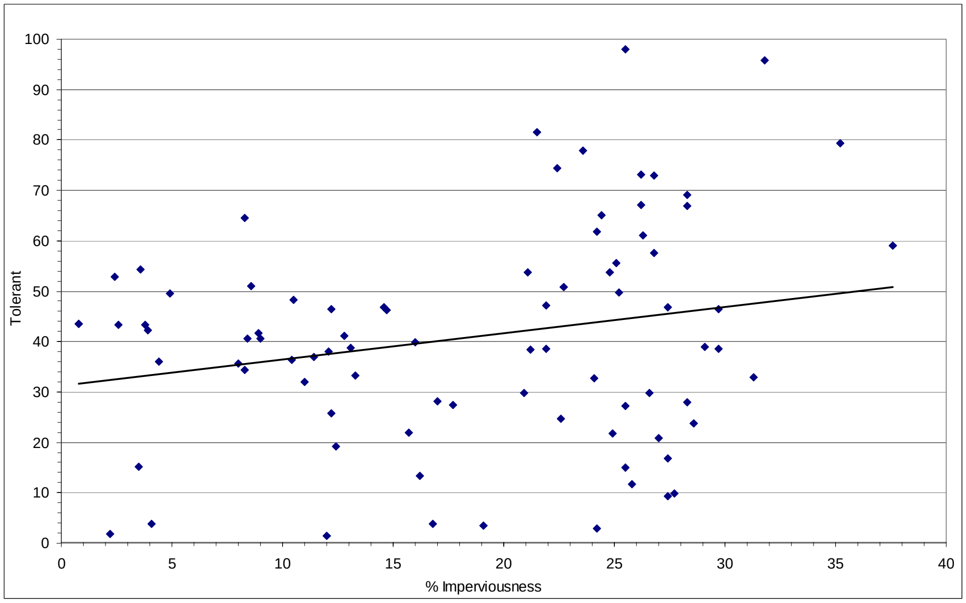
Abbreviations for tolerance ratings are as follows: T = Tolerant, M = Moderate, I = Intolerant. Abbreviations for trophic guilds are as follows: AHI –algivore/herbivore/invertivore, DAH – detritivore/algivore/herbivore, INV – invertivore, IP – invertivore/piscivore, PIS – piscivore.

CommonName	FamilyType	Tolerance	TrophicGuild	Non-Native	Benthic	Lithophils
Least Brook Lamprey	Lamprey	M	DAH			
American Eel	Eel	M	IP			
Alewife	Herring	M	AHI			
Gizzard Shad	Herring	M	AHI			
Chain Pickerel	Pike	M	PIS			
Eastern Mudminnow	Mudminnow	M	INV			
Common Carp	Minnow	T	AHI	X		
Goldfish	Minnow	T	AHI	X		
Golden Shiner	Minnow	T	AHI			
Rosyside Dace	Minnow	I	INV			X
Fallfish	Minnow	M	IP			
Creek Chub	Minnow	M	IP			
River Chub	Minnow	M	IP		X	
Cutlips Minnow	Minnow	I	INV			
Blacknose Dace	Minnow	T	INV			X
Longnose Dace	Minnow	M	INV		X	
Central Stoneroller	Minnow	M	DAH			X
Eastern Silvery Minnow	Minnow	M	AHI			
Common Shiner	Minnow	M	INV			X
Satinfin Shiner	Minnow	M	INV			X
Spotfin Shiner	Minnow	M	INV			
Bluntnose Minnow	Minnow	T	AHI	X		
Fathead Minnow	Minnow	T	AHI	X		
Comely Shiner	Minnow	M	INV			X
Spottail Shiner	Minnow	M	INV			
Swallowtail Shiner	Minnow	M	INV			X
Silverjaw Minnow	Minnow	M	AHI			X
White Sucker	Sucker	T	AHI			X
Creek Chubsucker	Sucker	M	INV		X	
Northern Hogsucker	Sucker	I	INV		X	X
Shorthead Redhorse	Sucker	M	INV	X	X	X
Blue Catfish	Catfish	M	IP	X		
Channel Catfish	Catfish	M	IP	X		
Yellow Bullhead	Bullhead	M	IP			
Brown Bullhead	Bullhead	M	IP			
Margined Madtom	Madtom	M	INV			
Banded Killifish	Killifish	M	INV			
Mummichog	Killifish	M	INV			
Mosquitofish	Livebearer	M	INV			
Potomac Sculpin	Sculpin	I	INV		X	
White Perch	Striped Bass	M	IP			
Redbreast Sunfish	Sunfish	M	IP			
Green Sunfish	Sunfish	M	IP	X		
Pumpkinseed Sunfish	Sunfish	M	INV			
Warmouth	Sunfish	M	IP	X		
Bluegill	Sunfish	M	INV	X		
Longear Sunfish	Sunfish	M	INV	X		
Redear Sunfish	Sunfish	M	INV	X		
Smallmouth Bass	Black Bass	M	PIS	X		
Largemouth Bass	Black Bass	M	PIS	X		
Black Crappie	Sunfish	M	IP	X		
Tessellated Darter	Darter	M	INV		X	
Fantail Darter	Darter	M	INV		X	
Greenside Darter	Darter	M	INV	X	X	
Shield Darter	Darter	I	INV		X	X
Yellow Perch	Perch	M	IP			

Figure C3: An example of the analysis completed to chose metrics for the Piedmont for metric #3, Percent Tolerant, for the Index of Biotic Integrity based on fish.



A) Watershed size versus the percentage of the sample tolerant individuals. Least impaired sites have less than 5% imperviousness and most impaired have greater than 25%. Average size for small watersheds is 7 km^2, medium 24 km^2, and large 56 km^2.



B. Correlation between percentage of the sample as tolerant individuals and percent imperviousness in the watershed.

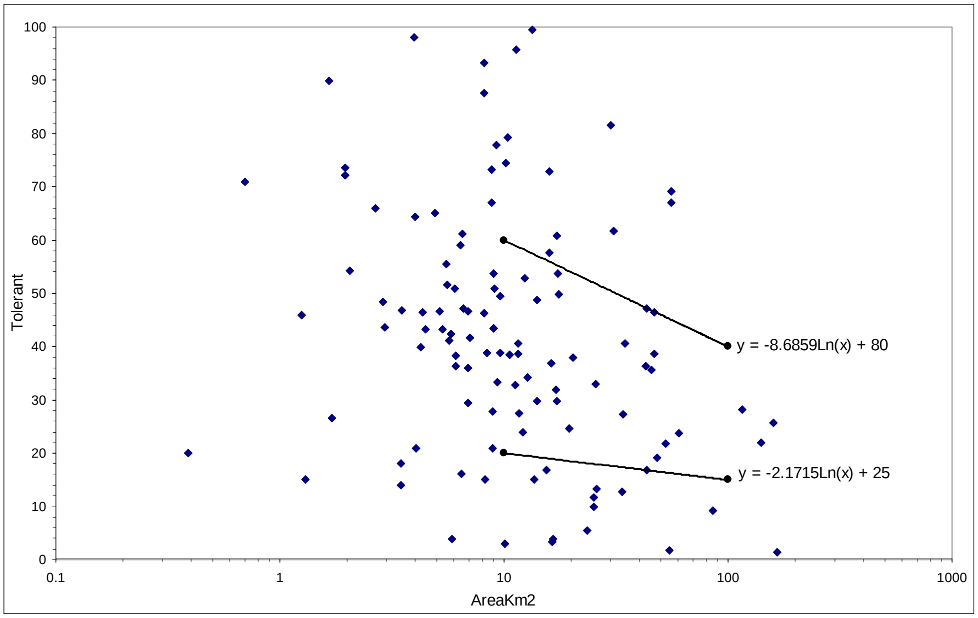


Figure C4: Example of tri-sectioning completed for metrics in the Piedmont.

Table C2: Scoring criteria for Fish Index of Biotic Integrity.

Piedmont	1	5
1. Number of Native Species	< 1.7648Ln(x) + 2.1597	> 2.3922Ln(x) + 5.1659
2. Number of Darter Species	<2	>2
3. Percent Tolerant	> -8.6859Ln(x) + 80	< -2.1715Ln(x) + 25
4. Number of Intolerant Species	<2	>2
5. Percent Generalists (AHI)	> -2.1715Ln(x) + 35	< 10
6. Percent Benthic Invertivores	< 2.1715Ln(x)	> 2.1715Ln(x) + 15
7. Percent Carnivores (IP + PIS)	< 2.1715Ln(x)	> -1.3029Ln(x) + 28
8. Percent Lithophils	< 20	> 40
9. Percent Anomalies	> 2	0
Coastal Plain		
1. Percent Tolerants	> -8.6859Ln(x) + 80	< -2.1715Ln(x) + 25
2. Percent Omnivores and Invertivores (AHI, DAH, and INV)	100	<= 92
3. Percent Non-tolerant Suckers	0	>= 2
4. Percent Dominant Species	> 69	<=40

x is watershed area in kilometers squared

Table C3: Classification rating for the Fish Index of Biotic Integrity.

Piedmont	Coastal Plain	RATING
> 34	-	Excellent
30 to 34	>17	Good
25 to 29	14 – 17	Fair
20 to 24	10 - 13	Poor
< 20	< 10	Very Poor

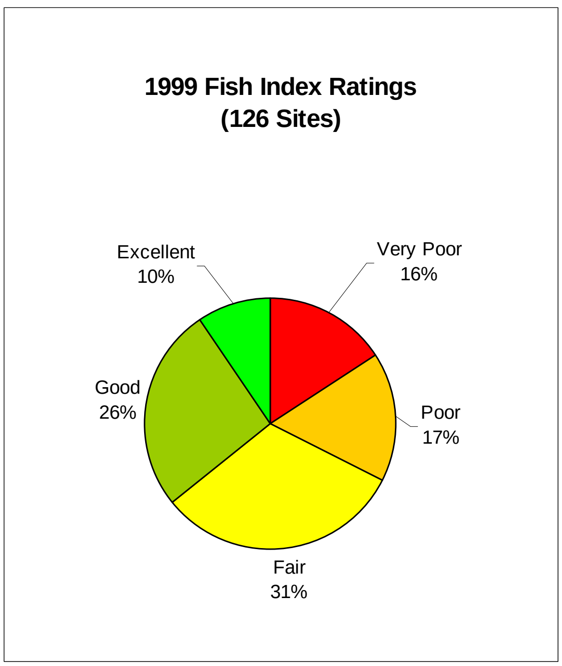
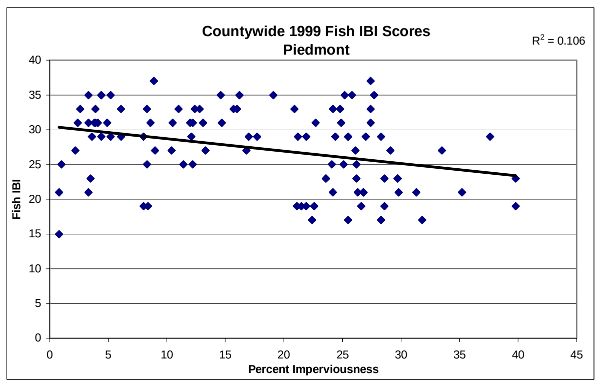
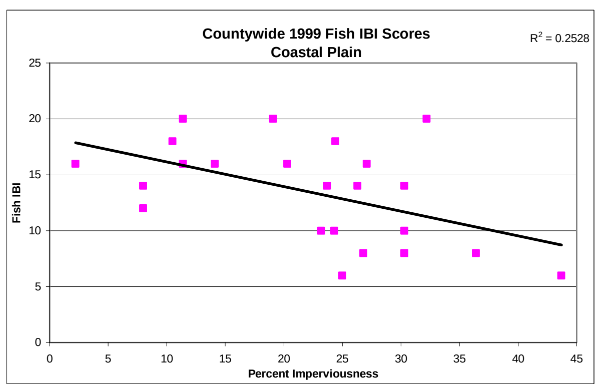


Figure C5: Ratings of 1999 biomonitoring sites for the Fish Index of Biotic Integrity.



A. Piedmont



B. Coastal Plain

Figure C6: Correlation between the Fish Index of Biotic Integrity and imperviousness based on the 1999 data.

4. 2004 Results at Individual Sites

Large differences in the percentage of sites score of the fish index between the 1999 and 2004 sampling seasons can be explained by the change in method of determining the sampling locations. The 2004 sites were randomly selected throughout the county resulting in a larger quantity of impaired sites whereas the 1999 sites were targeted to ensure a sampling location in all watersheds.

Table C4: Fish Index of Biotic Integrity and ratings for the 2004 sampling locations based on fish community data.

SiteID	Physiographic Province	Stream Order	Fish Index Score	Rating
AC0401	Piedmont	3	23	Poor
CU0401	Piedmont	4	17	Very Poor
DF0401	Piedmont	5	27	Fair
DF0402	Piedmont	2	29	Fair
DF0403	Piedmont	2	23	Poor
LR0401	Piedmont	3	25	Fair
PC0401	Piedmont	3	29	Fair
PH0401	Piedmont	2	23	Poor
SU0401	Piedmont	4	29	Fair
AC0402	Coastal Plain	3	8	Very Poor
AC0404	Coastal Plain	2	8	Very Poor
BE0401	Coastal Plain	2	12	Poor
CA0401	Coastal Plain	2	6	Very Poor
LH0403	Coastal Plain	2	8	Very Poor

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D. BACTERIA MONITORING PROTOCOL

1. Sampling Location and Methods

Sampling stations for the original Health Department bacteria monitoring program are located on the major streams and their main tributaries. Only 25 out of the 30 watersheds in Fairfax County have established sampling locations as, according to the Health Department Stream Water Quality Report, "five watersheds are small and do not contain any well-defined streams; therefore, these are excluded from the program." These five watersheds are Ryans Dam, Occoquan, Kane Creek, High Point, and Belle Haven. Four out of these five watersheds are in the down-zoned area along the Occoquan. The statement from the Health Department report and sampling scheme may be a legacy left over from when the bacteria sampling program started and access to streams within smaller watersheds may have been difficult and too time consuming. The sample station identification number is a two-part number identifying the watershed and the sample site. There are gaps in the sequential numbering system due to additions and eliminations of sample sites over several years. In 2004, there were a total of 80 sampling sites which were divided into nine sampling zones which were then sampled four times a year. The stream sample site locations have been evaluated for run-off potential and possible sources of pollution. The sites are located on tax maps and diagrams of the sites are available for reference. Past Stream Water Quality Reports and data can be found at:

http://www.fairfaxcounty.gov/service/hd/strannualrpt.htm#data.

2. Equipment Requirements

The following field equipment is required for bacteria monitoring:

- Data sheet (see Figure D-2) and pencils
- Nasco Whirl-pak, sterilized water sampling bags
- Sterile 500 ml plastic bottles
- Meters (YSI 85, YSI 556, and Accument Portable pH meters)
- Cooler with ice

3. Laboratory Procedures

All water samples are kept on ice and brought to the Health Department lab within six hours for analysis. The Stormwater Planning Division does not perform any laboratory analysis. All laboratory procedures used to determine concentrations of various parameters are defined in "Standard Methods for the Analysis of Water and Wastewater, 18th Edition", 1992. The fecal coliform procedure utilizes the Millipore filter and gives a direct count per 100 ml of sample. The determination of *E. coli* also uses a membrane filter to give a direct count per 100 ml of samples. The nitrate nitrogen is determined by the automated cadmium reduction method and phosphates are determined by persulfate digestion followed by the ascorbic acid colorimetry.

Figure D1: Example field data sheet for bacteria monitoring (front).

Water Chemistry: Streams Bacteriological Study

Fairfax County Health Dept, Laboratory
10777 Main St., #301, Fairfax, VA 22030

Sampling Zone 1
Report Results to: Danielle Derwin; 703-324-5616

Date Collected: ___________
Collected by: ____________
Team # _____
Meter type: ________

FIELD RESULTS

Sample ID #	*Point of Collection*	*Address/ Location*	*Time of Sample*	*pH*	*Sample Temp (°C)*	*Dissolved Oxygen (mg/L)*	*Specific Conductance (µS/cm)*
5-15	stream-Hickory Run (Difficult Run)	Roos Trail off of Manning St.					
5-16	stream-Difficult Run	Georgetwon Pike, near Difficult Run Park					
4-1	stream-Mine Run Branch (Pond Branch)	River Bend Road					
4-2	stream-Clarks Branch (Pond Branch)	Club View Drive					
4-3	un-named stream going into the Potomac (Pond Branch)	Blackberry Lane					
3-3	stream-Nichols Run	Springvale Road					
3-4	stream-Nichols Run	Beach Mill Road					
2-3	stream-Sugarland Run	near Intersection of Rt. 7 and Dranesville Rd.					
2-2	stream-Folly Lick Branch (Sugarland Run)	Cliveden Street					
2-4	stream-Sugarland Run	Spring St., in Sunset Business Park					

COMMENTS

Figure D2: Example field data sheet for bacteria monitoring (back).

Sample ID #	Lab Assigned Sample ID #	Sample ID #	Lab Assigned Sample ID #
5-15		3-3	
5-16		3-4	
4-1		2-3	
4-2		2-2	
4-3		2-4	

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